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FOR

METHOD FOR IMPLEMENTING AUTOMATIC PROTECTION SWITCHING (APS) USING CELL REPLICATION

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METHOD FOR IMPLEMENTING AUTOMATIC PROTECTION SWITCHING (APS) USING CELL REPLICATION

Field of the Invention

The present invention is related to networks. In particular, the method and apparatus of the present invention relates to Automatic Protection Switching (APS) using cell replication.

Background

Automatic Protection Switching (APS) is a means to provide redundancy on Synchronous Optical Network (SONET) equipment to guard against line failures.

There are three types of linear APS modes, namely, 1+1, 1:1 and 1:n. All three modes require that if any failures are detected in a working line, a switch to a protection line must be initiated in 10 msec and completed in 50 msec for a total of 60 msec.

In the linear APS 1+1 mode, for every working line, there is a corresponding redundant protection line. Traffic is carried by both the working and protection lines simultaneously.

In the linear APS 1:1 mode, for every working line, there is a corresponding redundant protection line. However, traffic is normally carried on the working line only. When a failure is detected in the working line, traffic is switched to the protection line.

In the linear APS 1:n mode, for every 'n' working lines, there is a corresponding redundant protection line. Traffic is normally carried on the

working lines only. When a failure is detected in a working line, traffic is switched to the protection line.

Currently, APS is implemented electrically through a multiplexer (MUX)/buffer combination on a line card. The disadvantages inherent in the current technology are many. For example, the APS ports must be in predefined locations, typically adjacent to each other. Additionally, the current scheme does not work at high speed signal transmissions. More specifically, although repeating signals at low speed is tolerable, the scheme breaks down at high speeds due to impedance mismatch and capacitive loading.

BRIEF SUMMARY OF THE INVENTION

A method for cell replication in which a request for data transmission and mapping information are received by a crossbar and a scheduler and are sent by one of a plurality of software configurable slot remap registers. The mapping information is indicative of a destination slot and a backup destination slot to which the data is to be transmitted. The method replicates the data by transmitting the data to the destination slot and to the backup destination slot when the data arrives at an input slot of the crossbar.

Other features and advantages of the invention will be apparent from the detailed description and drawings provided herein.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings in which like references indicated similar elements in which:

Figure 1 is a network diagram with an embodiment of a switch fabric with cell replication.

Figure 2 is a block diagram of an embodiment of a switch fabric.

Figure 3 is an exemplary block diagram of the switch fabric with a crossbar architecture.

Figure 4 is a switch plane with an embodiment of an APS cell replication feature.

Figure 5 illustrate exemplary registers.

Figure 6 is a flow chart showing the general steps of APS using cell replication.

DETAILED DESCRIPTION

A method and apparatus for implementing automatic protection switching using cell replication in a network switch fabric is disclosed. For one embodiment, a switch fabric has a slot that can be "dual-homed" to two slots. For example, if slot X is dual homed to slot X and Y, then any traffic that is destined to X will also go to Y. To avoid programming errors, this feature stipulates that one of the dual-homed slots must be itself. In other words, it is an illegal operation if slot X is dual-homed to Y and Z, where X, Y and Z are different values. For one embodiment, the dual homing feature is implemented through a switch fabric register referenced herein as a slot remap register that is under software control. The software may enable the feature on any slot at any time, disable the feature on any slot at any time and modify the slot numbers at any time.

When slot X is dual-homed to X and Y, a request that goes to either X or Y will be treated as if there is a request going to X and Y. A grant is issued to the requesting slot only if both requests (to X and Y) are granted. This applies to unicast and mulitcast traffic.

There are many intended advantages of the embodiment. For example, it is intended that the embodiment eliminate the predefined locations limitations of prior technology. Further, it is intended that no hardware upgrade be necessary in adding the embodiment as the embodiment is performed through software means.

Figure 1 is a network diagram with an embodiment of a switch fabric with cell replication. A network is a collection of computers, printers, routers, switches and other devices that are able to communicate with each

other over some transmission medium. Nodes in a network refer to an endpoint of a network connection or a junction common to two or more lines in a network. Nodes can be processors, controllers, or workstations. Nodes vary in routing and other functional capabilities and can be interconnected by links, and serve as control points in the network.

One embodiment is for a network switch ("switch") which is a chassis based, modular architecture having circuit boards configured to plug into the chassis. A switch is a device that allows a connection to be established as necessary and terminated when there is no longer a session to support.

In the exemplary network diagram, a network node 100 has a network switch 101 with a switch fabric 102. The switch fabric 102 has an APS cell replication feature 150 with a 1+1 implementation where for every working line, there is a corresponding redundant protection line. Traffic is carried by both the working and the protection line simultaneously. A network node 104 also has a network switch 105 having a switch fabric 106 with an APS cell replication feature with a 1 + 1 implementation. The two intermediate nodes 108 and 110 do not need an APS implementation because they are protected on both sides of the network by the APS cell replication features 150 of nodes 100 and 104.

In an alternate embodiment, the APS cell replication feature can be implemented to protect physical lines between the network nodes.

Figure 2 is a block diagram of one embodiment of a switch fabric. For one embodiment, a network switch 101, has three types of parts, namely a processor card 200, a switch card 202 (switch fabric 102) and a line card 204. The line card 204 interfaces traffic coming in and out of a physical port with

the switch fabric 102. The interface is accomplished through a switch fabric interface 205 that interfaces the switch fabric 102 with a line card 204 and a layer functions 207 which processes data received from and forwarded to the physical port through framers/transceivers $209_1 \ldots 209_N$ into an appropriate format. A processor card 200 is a form of a line card 204 and has the Central Processing Unit (CPU) 203, segmentation and reassembly (SAR) 211 and high level software.

There are a number of switch cards 202 in the system. For one embodiment, there are four switch cards 202. Each switch card 202 has the APS cell replication feature and has of a number of switch planes $206_1 \ldots . 206_N$, which are the basic elements of a switch fabric 102. For one embodiment, each switch plane 206 has a crossbar 213 and a scheduler 215. Both the crossbar 213 and the scheduler 215 are discussed in detail in the text accompanying Figures 3 and 4.

Between every line card 204 and a switch plane 206 there is a physical connection with one direction of traffic going in to the switch fabric 102 and a direction of traffic going out of the switch fabric 102, resulting in a full duplex connection. For example, given sixteen switch planes, there are sixteen connections between the line card 204 and the switch fabric 102.

For one embodiment, the APS cell replication feature is implemented in the switch fabric 102, more specifically through the crossbar 213 and the scheduler 215.

Figure 3 is an exemplary block diagram of the switch fabric with a crossbar architecture. Figure 3 is illustrated with ingress slots 300 and egress slots 302, which are part of the same line card 204, but logically separate. Once

the traffic arrives at a line card 204, requests for transmission made for the traffic comprised of cells are sent to the switch planes $206_1 \ldots 206_N$ of the switch fabric 102.

A switch plane 206 receiving a request determines whether to grant the request or not. If the switch plane 206 determines to grant the request, then in the next time slot the line card 204 submits a cell (also referred to herein as data) and the switch plane 206 switches the destination of the cell to an appropriate alternate destination.

There are a number of line cards 204 submitting requests to the switch fabric 102. The switch fabric 102 determines which requests to provide grants to. The traffic is then sent to the switch fabric 102 where the traffic is "switched" or "routed" to the appropriate destination slots.

The APS cell replication feature repeats a connection using the switch fabric 102. More specifically, a number of registers, referred to herein as slot remap registers, are programmed into each switch planes $206_1 \ldots 206_N$, such that when traffic is passed to an egress slot 1 (ES1), the traffic is also copied to an egress slot 2 (ES2) where ES1 (active line) is protected by ES2 (standby line). Thus, unlike the prior technology that repeats connections electrically, the APS cell replication feature repeats the connections logically through software control and there is no limitation on transmission speed. Additionally, since the APS cell replication feature is controlled logically through software control, a given line can protect "n" or any combination of lines, whereas with prior technology, lines physically next to each other were assigned to each other for APS protection.

Figure 4 is a switch plane with an embodiment of the APS cell replication feature. For one embodiment, a switch plane having the APS cell replication feature may be implemented with a switch ASIC 400. For one embodiment, there are two entities within the switch plane 206, namely a crossbar 213, which includes gates to direct traffic, and a scheduler 215 that controls the crossbar 213.

For one embodiment, the scheduler 215 has N signal inputs $408_1...408_N$ and N signal outputs $410_1...410_N$ and provides control signals $406_1...406_N$ to the crossbar 213. The signal inputs $408_1...408_N$ to the scheduler 215 are requests for data transmission through the crossbar 213, and the signal outputs $410_1...410_N$ are grants (i.e. acknowledgements to the requests).

The crossbar 213 has N data in signals $412_1...412_N$ and N data out signals $414_1...414_N$ and is an N by N spatial crossbar that may have N concurrent events such as N data coming in and N data going out. Only data for which a request for transmission is granted by the scheduler 215 is processed through the crossbar 213.

Both the crossbar 213 and the scheduler 215 receive mapping information 422 from software configurable slot remap registers $416_1...416_N$. Mapping information 422 identifies the data out destination slots $414_1...414_N$ to which data is to be transmitted through the crossbar 213.

For one embodiment, each of the N slot remap registers $416_1...416_N$ corresponds with a sequential one of "data in" signals $412_1...412_N$ of the crossbar 213. For example, slot remap register 416_1 corresponds to data in signal 412_1.

When a request comes in to, for example, input slot 408_1 of the scheduler 215, the scheduler 215 receives the corresponding mapping information 422 from the slot remap register 416_1. The scheduler 215 then determines whether the destination slot and the backup destination slot as identified by the mapping information 422 for input slot 408_1 are valid based on the result of arbitration (i.e., whether the destination slot and the backup destination slot are available). For example, the scheduler 215 may grant requests based on some type of priority scheme whereby a grant with the highest predetermined priority is granted a request first and so on. The form of arbitration to select which destination slot to grant next may vary and is not limited to a priority scheme based arbitration.

Once validity is confirmed, the scheduler 215 transmits a control signal 406 to the crossbar 213 which indicates that 412_1 is permitted to send a cell to its intended destination slot and the backup destination slot. Additionally, an acknowledgment 418 is sent back to the source 420 of the request, such as an ingress line card. When the data comes in to the crossbar 213, the crossbar 213 knows which route to take the data by the slot identified by the mapping information 422.

Figure 5 illustrates exemplary slot remap registers. In the illustrated embodiment, there are fourteen registers with five bits and the most significant bit, bit four, determines whether the corresponding traffic is to go to two slots (i.e., "redundant mode"). The four lower bits determine the identity of the current backup slot (i.e., "remap value"). Each register of the slot remap registers $416_1 \ldots 416_N$ may correspond with one slot (one-to-one correspondence with 14 registers and 14 slots). The backup slot is assigned to 1

to N slots. In an alternate embodiment, a backup slot is assigned to one specific slot.

The slot remap registers $416_1 \ldots 416_N$ are software configurable. The setting of the slot remap registers $416_1 \ldots 416_N$ may be changed at any given time, the effect of which will take place the next time count. There are two scenarios for which the slot remap registers $416_1 \ldots 416_N$ may be re-programmed to match slots with a changed backup slot. In one scenario, a system that is non-redundant is to be made redundant. In a second scenario, a system's network topology is changed, for instance, network topology may change as more connections are added to the system and connections are deleted due to an increase in network users. Alternatively, the topology of the user changes and the user may want to reconfigure the APS logic. Thus, there are three options for the APS logic, namely, addition, deletion, or reconfiguration of the backup slots. The slot remap registers $416_1 \ldots 416_N$ may be re-programmed accordingly.

Figure 6 is a flow diagram illustrating the general steps followed by one embodiment. In step 601, a request comes in to the scheduler 215. In step 602, the scheduler 215 receives the corresponding mapping information 422 from the slot remap registers $416_1 \ldots 416_N$. In step 603, the scheduler 215 then determines whether the slot and the backup slot to grant the request to are valid (i.e., available). If the requests are not valid, then a grant will not be issued to the source of the request. In step 604, once validity is confirmed, the scheduler 215 transmits a control signal 406 to the crossbar 213 that indicates that the slot and the backup slot are available. In step 605, when data arrives at the input slot of the crossbar 213, the crossbar 213 transmits the data to its

destination slot and replicates the data cell by transmitting the data to the duo-homed backup destination slot.

What has been described is a method and apparatus that logically duplicates cells in the switch fabric as opposed to performing the APS electrically.

In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention as set forth in the appended claims. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.